TECHNICAL SERVICE CENTER
Denver, Colorado

South Diversion Dam Removal
Reconnaissance Report

Battle Creek Project, California

Prepared by
Technical Service Center

U.S. Department of the Interior
Bureau of Reclamation

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SOUTH DIVERSION DAM REMOVAL

A. Introduction

Declining salmonid populations in the Sacramento River system have resulted in increased restoration efforts to preserve and enhance current populations, while addressing the needs of various stakeholders. Studies are currently underway to improve anadromous fish populations on 39 miles of Battle Creek (a cold water tributary of the Sacramento River) above the Coleman National Fish Hatchery and below natural barrier falls. These studies are being conducted by several agencies and technical contractors under the guidance of the Battle Creek Working Group. The Battle Creek Working Group is a broad-based stakeholder group which includes representatives from state and federal resource agencies as well as from environmental, local, agricultural, power, and urban stakeholder communities, and was formed in 1997 to evaluate various alternatives for the development of a final restoration plan. A salmon and steelhead restoration plan is being developed by Kier Associates of Sausalito, California [1]. The California Department of Water Resources (DWR) is developing reconnaissance-level designs and cost estimates for various fish ladder and fish screen locations, which will provide upstream passage for adult salmon and steelhead, and downstream passage for juvenile fish [2]. The Bureau of Reclamation (Reclamation) was requested to develop reconnaissance-level designs and cost estimates for the removal of two diversion dams on the North Fork, and one diversion dam on the South Fork, in concert with these studies. The removal of Wildcat, Eagle Canyon, and Coleman Diversion Dams is described in Reclamation's "Battle Creek Dam Removals - Reconnaissance Report" dated January 1999 [3]. A reconnaissance-level design and cost estimate for the removal of South Diversion Dam, located on the South Fork, was also requested and is the subject of this report. A Project Location Map is provided in Appendix A.

B. Existing Project Features

South Diversion Dam is located on the South Fork Battle Creek, about 6 miles southeast of Manton, California, and 11.8 miles upstream of Coleman Diversion Dam, on land owned by the Pacific Gas and Electric Company (PG&E). The drainage area above the South damsite is about 67 mi^2, and includes a natural barrier falls at the confluence with Panther Creek about 2 miles upstream. The diversion dam provides up to 100 ft^3/s to the South Canal for power generation at the South Powerhouse (which is near the Inskip Diversion Dam, located 6.4 miles downstream), and was originally constructed around 1910 as a timber crib dam. The principal features of the existing dam and canal are shown in Appendix A (Exhibit L-18) and Appendix B (photographs 1 through 6).

The present gravity structure is of steel "bin-wall" construction, with an overflow crest length of 100 feet at elevation 2027.1, and a crest width of 16.5 feet. The structure faces are vertical, and rise up to 20 feet above the streambed surface. The nonoverflow sections are 45 feet long on the left abutment (to elevation 2035.1), and 10 feet long on the right abutment (to elevation 2032.1). The structure utilizes a system of adjoining closed-face bins generally 10 feet long, consisting of lightweight galvanized steel members bolted together and backfilled with native alluvial channel materials (gravel and cobbles). The overflow crest was capped with reinforced concrete, but sustained heavy abrasion damage during flood flows in 1997 and was recently covered with a ½-inch-thick welded steel plate. A steel denil-type fish ladder is attached to the downstream face of the overflow crest structure, and extends 68 feet from the right end of the structure beneath a steel deflector plate (shown in photograph 3). Fish ladder releases are

controlled by a 2- by 2-foot slide gate (invert elevation 2023.9). These features replaced the original timber crib dam and fish ladder shown in Exhibit L-17 (in Appendix A). The reservoir behind the dam is mostly filled in with sand, gravel, cobbles, boulders, and debris, so that the depth of water probably averages only two to three feet below the dam crest.

A 12-foot-wide by 8-foot-high radial sluice gate is provided on the right abutment within a reinforced concrete structure, with an invert at elevation 2020.6. This represents a sluiceway capacity of about 600 ft^3/s at the dam crest. The South Canal intake structure is located to the right of the radial sluice gate and includes a steel trashrack on a concrete sill, and a 60-inch-diameter slide gate at the inlet portal of an unlined tunnel section. The slide gate has an invert at elevation 2020.6 (a few feet below the concrete sill elevation), and a gate operator above a concrete deck at elevation 2034.6. The South Canal extends nearly 6 miles to its confluence with the Cross-Country Canal, where both canals combine to form the 3,555-foot-long Union Canal before entering the South Powerhouse penstock. The South Canal consists of 7,302 feet of rock tunnel sections approximately 8-feet-wide by 8-feet-high; 2,628 feet of metal flume sections (type #132) with a 3.5-foot-radius on steel supports; and 20,293 feet of excavated channel sections (16,370 feet unlined and 3,923 feet lined) with a bottom width of 7 feet, a top width of 11 feet, and a flow depth of 5 feet.

The dam is not under the jurisdiction of the DWR Division of Safety of Dams, due to its small size (less than 25 feet in height, and less than 50 acre-feet of storage). The Federal Energy Regulatory Commission (FERC) has classified the South Diversion Dam as a low hazard structure, representing no danger to human life in the event of failure. The diversion dam was inspected by FERC in July 1997, at which time the abrasion damage to the concrete cap was noted and the installation of a steel cap was proposed [4]. The facility was visited briefly by Reclamation personnel on July 10, 1998, at which time about 200 ft^3/s was being released over the dam crest and an estimated 100 ft^3/s was being diverted into the canal, which prevented a close inspection of the structures.

C. Streamflow Diversion Requirements and Construction Sequence

Total streamflow on Battle Creek has been recorded at the Coleman National Fish Hatchery near Cottonwood, California (USGS gauging station No. 11376550) since October 1, 1961. Peak flows recorded on Battle Creek since 1961 have occurred during the months of October through May. Minimum total streamflow for the 357 mi^2 drainage basin is shown to be approximately 250 ft^3/s for the 35 years of record.

Reliable, detailed streamflow data do not currently exist for South Fork Battle Creek. Median monthly streamflow data recorded at the Coleman National Fish Hatchery for three “normal” water years (1985, 1989, and 1993) were averaged and apportioned for the South Diversion damsite by Reclamation, using the square root of the ratio of the drainage areas, in table 1 below. These estimates can be used as an upper bound for determining streamflow diversion requirements for removal of the dam under normal conditions. The Battle Creek Working Group selected 1989 as a typical water year for analysis and modeling purposes. Resources Management International (RMI) used the simple ratio of drainage areas (67/357, or 19 percent) to estimate inflow at South Dam, based on the 1989 stream gauge records. PG&E estimated inflow at South Dam based on recorded and interpolated gauge information [1].

Table 1. - Streamflow Estimates Using Square Root Relationship (Normal Years) - in ft^3/s

Calendar Months	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1985 Streamflow	357	521	471	391	376	401	517	416	342	266	254	270
1989 Streamflow	205	259	265	341	298	1060	776	479	381	270	229	245
1993 Streamflow	134	204	237	701	640	732	751	785	696	384	291	229
Average of 3 years	232	328	324	478	438	731	681	560	473	307	258	248
At South Dam	101	142	140	207	190	317	295	243	205	133	112	107

In order to minimize the streamflow diversion requirements at the damsite during removal activities, thereby minimizing removal costs, all instream demolition work should be scheduled in September or October. This will also serve to minimize potential impacts on spring-run and winter-run salmon. Streamflow estimates for September and October at the South Diversion Dam are 107 ft^3/s and 101 ft^3/s by Reclamation (from table 1), 46 ft^3/s and 38 ft^3/s by RMI [1], and 34 ft^3/s and 26 ft^3/s by PG&E [1]. A streamflow diversion requirement of 60 ft^3/s was assumed for this study.

D. Proposed Plans for Dam Removal

1. Site access and mobilization. - Site access to South Diversion Dam is provided by traveling from Manton Road approximately 4 miles along Forward Mill Road to Ponderosa Way, then continuing along the gravel/dirt road for 3 miles to the PG&E facility access road. The access road is about 2.5 miles long, and passes over a narrow timber bridge crossing the South Canal to a switchback turn and parking area. From the parking area, a foot path extends along the canal bank to the dam. Heavy construction equipment could travel up the rocky stream channel (during low flow conditions) about 1,000 feet to the dam, provided applicable permits are first obtained. This method of access was used in 1978 to construct the existing steel bin-wall structure. Some channel and access road improvements may be necessary to accommodate the construction equipment required for dam removal. The damsite is owned by PG&E, but the access road crosses private property. Necessary approvals for site access and any improvements would have to be obtained from private landowners. Electric power (110 V) is currently available at the site via an overhead transmission line.

It is assumed that a contractor staging area could be established along the access road within a mile of the damsite. Helicopter service, if needed, may be available from Redding Air Services, Redding, California (phone 530-221-2851) or from Westwind Helicopters, Inc., Rancho Cordova, California (phone 916-852-0476). Westwind Helicopters provided helicopter service for delivery and installation of the steel plate sections for the overflow crest. The use of a helicopter at the damsite

could require removal of the power transmission line. The cost estimate for this study assumed a helicopter would be required for removal of the metal flume sections only.

2. Streamflow diversion. - Using the diversion assumptions outlined in the previous section, a streamflow diversion requirement of 60 ft^3/s was adopted for this study. The existing 12- by 8-foot radial sluice gate could be used to drain the reservoir under these flow conditions to about elevation 2022, or about 5 feet below the existing dam crest. One 10-foot-long section of the bin-wall could be breached initially to provide additional reservoir drawdown for removal of the remaining bin-wall sections.

3. Structure removal. - Features to be removed at South Diversion Dam would include the steel bin-wall overflow and nonoverflow sections, the denil-type fish ladder structure and slide gate, the gated sluiceway, and the metal flume sections along the South Canal. A potential candidate for retention, however, is the canal intake structure on the right abutment of the dam. One of the few remaining features from the original construction, the gated intake structure could be retained to mark the dam location following removal, while serving to seal the tunnel inlet portal (by welding closed) and minimize removal costs. Cost estimates for both full and partial dam removal are included in this study. Further consideration of the retention of any structures at the site must consider any potential liability risks. All original structures would be fully documented as required in an Historic American Engineering Record (HAER) for the damsite.

Using the available diversion capacity to maintain the reservoir level below the crest of the overflow section would allow demolition activities to begin on the dam crest. The steel plate and reinforced concrete cap on the overflow crest would first be removed by cutting or breaking into smaller sections for handling purposes. Backfill within the nonoverflow and overflow sections would be excavated and wasted on-site. The steel bin-wall components would either be unbolted or cut apart for removal from the site. Unbolting would take more effort, but would provide a salvage value of the components for potential use elsewhere. (The cost estimate assumes all components would be cut for ease of removal, and wasted.) The steel components probably extend a few feet below the desired final grade, but would be removed in their entirety. Backfill would only be excavated to the desired final grade. Some work would necessarily be performed by heavy equipment operating in the flow, with water depths averaging less than three feet. The cost estimates assume the waste concrete, steel, and other construction materials would be demolished using mechanical methods and would be removed from the damsite by hauling downstream to the canal crossing and access road. Blasting could be considered for demolition of the reinforced concrete structures, but was not assumed for this study. A helicopter could be used to airlift waste materials out, but probably for a higher overall cost.

The cost estimate for partial removal assumes removal of all features at the damsite except for the canal intake structure and associated mechanical and miscellaneous metalwork items. The slide gate would be permanently closed by welding, and access to the gate operator would be eliminated for safety reasons. A concrete plug could also be placed at the gate as a precaution.

The metal flume sections would be disassembled and airlifted out in a manner similar to their original construction, and as described in detail for removal of identical sections along the Eagle Canyon Canal [3]. The cost estimate for full removal also includes the complete removal of all reinforced concrete footings along the metal flume alignment; the cost estimate for partial removal assumes the concrete footings would be left in place. Further consideration of the retention of concrete footings along the flume alignment must consider any potential liability risks and the desires of the private landowners. Both cost estimates include backfilling of the excavated canal channel sections using local materials, and the construction of concrete plugs at tunnel portal locations which would be accessible to the public. (Nine or 10 concrete plugs were assumed for the cost estimates; however, up to 10 additional concrete plugs may be required following further investigation, to plug all remaining tunnel portals regardless of tunnel location and length.)

4. Site restoration. - Backfill within the overflow and nonoverflow sections would be removed to provide natural-looking contours approximating the original pre-dam site conditions. All waste concrete and steel items would be removed from the site. The partial dam removal plan would retain the canal intake structure and ancillary items on the right abutment, as well as the concrete footings for the South Canal flume sections. Sediment management at the site is discussed in Section F. A final site inspection should be performed following the winter and spring runoff to confirm the adequacy of the dam removal work.

E. Waste Disposal

It is assumed that onsite disposal of construction debris and waste materials would not be practicable at this site. Some onsite disposal may be possible inside the tunnel, but was not assumed for this level of study. In general, waste materials would be disposed of by burial at a suitable waste disposal site. If a suitable site cannot be found nearby, a commercial site, such as Anderson-Cottonwood Disposal (phone 530-221-4784), may be used. This study assumes a disposal site can be located within about 1 mile of the damsite.

Steel bin-wall components, metal flume components, the fish ladder, mechanical items, and miscellaneous metalwork removed from the South Diversion Dam and South Canal may have some commercial value, and should be salvaged to help offset removal costs, if practicable. The California Department of Fish and Game, local residents, and area contractors may have an interest in some of these items. Short's Scrap Metal (phone 530-243-4780) or other area recycling firms may also be willing to purchase them. Cost estimates for this study do not include any salvage value for any items removed from the dam or canal.

Hazardous materials which may be encountered as a result of the dam removal work could include minor amounts of lead-based paints, oil, and grease. Site assessments should be performed to establish all potential environmental hazards existing at the damsite prior to final designs. A visual inspection and regulatory/literature search should first be performed to establish the possible presence of hazardous materials, followed by a more detailed evaluation to confirm the presence and extent of the hazardous materials and to plan appropriate actions for removal [5]. For the purpose of the current study, no

hazardous waste is assumed to be present at this site which would significantly impact the cost of dam removal.

F. Sediment Management

Sediment has almost completely filled the reservoir impounded by the diversion dam. The site topography and photographs indicate alluvial materials at or near the overflow crest elevation along most of its length, except near the right abutment where the fish ladder and radial sluice gate are located. The topographic contours in the stream channel suggest a difference of 12 to 13 feet in elevation between the upstream and downstream beds at the dam. The upstream channel is actually divided by a large accumulation of gravel, cobbles, and boulders extending over 200 feet upstream from the dam.

Average channel slopes along the South Fork Battle Creek were determined from USGS maps, indicating steep slopes between 0.033 and 0.036 exist upstream from the influence of the diversion dam. Channel slopes closer to 0.020 exist in the reservoir sediment at the dam. A simple geometric analysis was performed to approximate the volume of sediment trapped behind the dam as a triangular wedge, based on an original bed slope of 0.033, an average sediment depth of 12 feet, and a channel width equal to the overflow crest length. This results in an estimate of 9,000 yd^3 of trapped sediment. When the local channel slope in the sediments and the existing upstream channel bar are considered, a total accumulated sediment volume of over 20,000 yd^3 may be determined.

No formal sediment sampling or classification has been performed at this site. Based on the reconnaissance-level studies performed for removal of other diversion dams within the Battle Creek Project [3], the average channel slope above South Diversion Dam is found to be very comparable to the estimated slope for North Fork Battle Creek upstream of Eagle Canyon Dam. Since the high flow (average annual peak flow) and low flow (minimum average monthly flow) values may be around 40 percent lower due to the smaller drainage area upstream of South Diversion Dam, and the stream channel is significantly wider, generally smaller sediment sizes would be expected behind South Diversion Dam than at the Eagle Canyon site. The expected sediment sizes behind South Diversion Dam would still be classified as gravels, cobbles, and boulders, however, which is supported by photographs of the site. Because there are no significant quantities of silts or fine sands expected to be present within the sediment, there should not be a large increase in turbidity of the water or any problems associated with the transport and deposition of fine material during natural erosion. In addition, the sediment should not present any contamination problems, since the streams pass through relatively undisturbed and uninhabited land.

It is expected that most of the sediment behind South Diversion Dam would eventually be transported downstream following removal of the dam. Based on experience with gravel bed streams, it is likely that the sediment behind the dam would quickly come to equilibrium with the stream after an initial slug of sediment is transported downstream [6]. This initial slug of sediment, if it remains as a coherent wave, would have the potential of causing some problems downstream, including increased flood stage, localized blockage of facilities along the river, and damaged fish habitat. Whether it remains as a slug of sediment or dissipates and distributes itself over the downstream

reach is likely a function of particle sizes. It is expected that, if there is a large range of particle sizes and no one size class dominates, the sediment wave would quickly dissipate. This is because each size class would move at its own rate.

To prevent the possibility of a slug of sediment moving downstream, it is suggested that a channel be excavated upstream from the damsite through the sediment. Mechanical channelization can help the stream return to its pre-dam condition more quickly and with less adverse environmental consequences than through natural erosion alone [7]. Creating such a channel within the deposited sediment would also benefit fish passage. Without such a channel, there could be a barrier to fish passage after the dam is removed. The excavated channel should extend about 900 feet upstream from the damsite, ranging in depth from 12 feet at the dam to daylight at the upstream end, for a channel bed slope of 0.033. The bottom width should be about 20 feet, and the side slopes should be about 2.0H:1.0V, or equal to the angle of repose of the sediments. Much of the sediment can be distributed along the banks of the channel. For cost estimating purposes, an estimated 5,000 yd^3 of material is assumed to be removed from the channel and hauled to a land disposal site within about 1 mile. (This would require 500 trips using 10 yd^3 capacity trucks - a conveyor belt could be considered to facilitate this operation.) The excavated channel would be intended only to help start the erosion process, and would not be considered a stable channel. The river would be expected to further alter the channel geometry to suit itself.

G. Project Schedule and Estimated Costs

1. Development of Construction Logic and Durations

Dam removal activities at the South Diversion Dam are assumed to be performed in September or October, during the historic low flow period. Flume removal activities are assumed to be essentially independent of the dam removal (stream channel) work, but would probably be performed concurrently. None of the activities associated with removal of the South Diversion Dam and decommissioning of the South Canal is dependent upon the removal or modification of any other features of the Battle Creek Project.

Preconstruction activities include the collection of design data, the preparation of final designs and specifications, and issuance of the specifications package for the dam removal project, which is estimated to take approximately 9 months. The bidding process is assumed to take 4 to 6 weeks, at which time the bids would be opened. Concurrent environmental protection and permitting activities may require 2 to 3 months to get agreement and approvals on the action to take, 3 months to prepare an Environmental Assessment (EA) and receive the expected Finding of No Significant Impact (FONSI), and between 1 and 3 months to get the necessary 404 and 401 permits required for construction to begin.

Administrative activities include an estimated 30 calendar days for contract award and notice to proceed following the bid opening. It is assumed that construction access and demolition plans would be required to be submitted, for approval, by the contractor, which may require 30 calendar days to prepare and 20 calendar days to approve. These activities need to be completed in time to permit site mobilization by early September.

Dam removal activities at South Diversion Dam would begin with site mobilization and reservoir drawdown to approximately elevation 2022, or the lowest level possible, which requires operation of the radial sluice gate full open to pass streamflow. Cat 315B excavators, or larger, would be delivered to the site to facilitate streamflow diversion and begin demolition of the gravity bin-wall structure. The fish ladder (estimated 4,000 lbs) and the steel plates on the overflow crest (estimated 38,000 lbs) would be removed, and the underlying concrete cap (estimated 20 yd^3) would be demolished, within less than 1 week. The bin-wall sections contain a total of approximately 1,500 to 2,000 yd^3 of granular backfill material which would be excavated and dispersed around the damsite. Removal of the steel bin-wall components would lag slightly behind the backfill excavation, and should be completed within about 2 weeks. Mechanical excavation of the radial gate structure (estimated 70 yd^3) and the canal intake structure (estimated 20 yd^3) could require up to 2 weeks to complete. Excavation of a pilot channel within the upstream sediment (including the removal of 5,000 yd^3 of material) would also require about 2 weeks, but could be performed concurrently with the dam removal activities. Site mobilization, demobilization, and final cleanup would extend the overall duration for all dam removal activities to between 6 and 8 weeks.

Removal of 2,628 feet of metal flume from the South Canal would be accomplished by airlifting out bundled materials using a helicopter, with two 20-foot spans removed about every 3 hours, for a total duration of about 5 weeks. The metal flume is assumed to weigh approximately 100 pounds per foot of length, with supports and miscellaneous metalwork assumed to increase the total weight by about 30 percent. Concrete footings for flume supports are assumed to average about 1 cubic yard for each support spaced on 20-foot centers. Concrete footing removal, required under the full removal plan, would likely follow right behind the flume removal activities and would use the same helicopter to haul out about 2 yd^3 (8,000 pounds) of waste concrete every 4 hours, for a total duration between 6 and 7 weeks. The placement of concrete plugs at tunnel portals would be performed concurrently with the flume removal activities, and would use existing dirt roads for access wherever possible. Backfilling of the canal channel using local materials (estimated 35,000 yd^3) should take no more than 7 or 8 weeks to complete.

These estimated durations would permit all removal and restoration activities to be completed within the September-October time period.

2. Field Cost Estimates for Dam Removal

The estimated field cost for removal of all features associated with South Diversion Dam, including a 25 percent allowance for contract contingencies, is $2,300,000.

The estimated field cost for partial removal of South Diversion Dam, which would retain the canal intake structure, some mechanical items and miscellaneous metalwork, and concrete footings along the canal flume alignment, is $1,850,000.

Detailed cost estimate worksheets are provided in Appendix C.

3. Design and Construction Management Costs

For the reconnaissance-level estimates and for comparison purposes, non-contract costs are assumed to represent an additional allowance of 20 percent for engineering designs, 15 percent for construction management, 5 percent for contract administration, and 3 percent for environmental mitigation, or a total of 43 percent of the estimated total field cost (including contingencies). Total estimated costs for both full and partial removal of South Diversion Dam are summarized in table 2 below. Real estate costs are not included in these estimates.

Table 2. - Total Estimated Costs for Full and Partial Removal, South Dam

Removal Option	Field Cost	Non-Contract Cost	Total Project Cost
Full Removal	$2,300,000	$1,000,000	$3,300,000
Partial Removal	$1,850,000	$850,000	$2,700,000

H. Conclusions

Removal of South Diversion Dam and South Canal is technically feasible, and would require up to 2 months to accomplish in the field, for a total project cost between $2,700,000 and $3,300,000 (including contingencies and non-contract costs), depending upon the final removal requirements for the concrete footings along the canal flume alignment, and the retention of the canal intake structure at the dam. Reconnaissance-level field cost estimates for both full and partial dam removal are provided in Appendix C.

Dam removal would provide unobstructed passage in South Fork Battle Creek for anadromous fish, without the need for special fish passage structures at the damsite. Minimal adverse environmental impacts would be expected. All steel bin-wall components, waste concrete, reinforcing steel, mechanical items, and miscellaneous metalwork would be removed from the damsite, including 2,628 lin ft of metal flume along the canal alignment. If acceptable, the original canal intake structure and the concrete footings for the flume could be retained to minimize project costs, although potential liability issues must be addressed.

Erosion of much of the sediment behind the dam by natural river flows should produce satisfactory results. Significant quantities of fine materials are not present behind the dam, and therefore should not cause turbidity problems or other environmental impacts normally associated with such sediments. Some mechanical removal of reservoir sediment may be required to facilitate streamflow diversion and/or for removal of the dam structure to the original streambed elevation. A pilot channel should be excavated through the sediment upstream of the dam, to provide easier fish passage and prevent the possibility of the formation of a sediment wave which could adversely affect the downstream channel.

I. Additional Investigations for Future Studies

The following items should be completed for any future dam removal studies for the project:

1. Extend the site topography upstream and downstream to include the downstream site access road and the upstream sediment, and use the current datum (above mean sea level) rather than an arbitrary datum.

2. Obtain detailed drawings of the existing facilities, for use in estimating quantities and for inclusion in the HAER, if needed to document the damsite. Include pertinent construction drawings, correspondence, and photographs, if available, especially those related to the recent bin-wall construction and for construction of the metal flume.

3. Identify and perform additional studies related to cultural resources, species of special concern, and all other issues pertaining to compliance with the National Environmental Policy Act (NEPA).

4. Determine final limits of structure removal (features to be removed and features to be retained), based on economic, public safety, and other considerations.

5. Obtain channel cross-sections and gradations for further sediment analysis.

6. Evaluate site access improvements required for construction activities.

References

[1] Kier Associates, “Selected Portions of the Battle Creek Salmon and Steelhead Restoration Plan that Pertain to Anadromous Fish Habitat Upstream of Coleman National Fish Hatchery,” Sausalito, California, September 15, 1998 (draft).

[2] California Department of Water Resources, “Engineering Investigation of Anadromous Fish Passage in Upper Battle Creek,” Division of Planning and Local Assistance, Northern District, Red Bluff, California, July 28, 1997.

[3] Bureau of Reclamation, “Battle Creek Dam Removals - Reconnaissance Report,” Technical Service Center, Denver, Colorado, January 1999.

[4] Federal Energy Regulatory Commission, “Operation Report - Pacific Gas and Electric Company - Project No. 1121-CA - Battle Creek Project,” San Francisco Regional Office, San Francisco, California, August 19, 1997.

[5] American Society of Civil Engineers, *Guidelines for Retirement of Dams and Hydroelectric Facilities*, Task Committee on Guidelines for Retirement of Dams and Hydroelectric Facilities, Hydropower Committee, Energy Division, New York, New York, 1997.

[6] Parker, G., St. Anthony Falls Hydraulic Laboratory, personal communication, September 4, 1998.

[7] Morris, G. L., and Fan, J.., *Reservoir Sedimentation Handbook*, McGraw-Hill, New York, 1998.